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PRIMARY RESEARCH

An integrated model of advanced artificial intelligence capability in higher education

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Keywords

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Abstract

Despite debate, challenges and promised benefits of artificial intelligence has opened new opportunities for Higher Education Institutions with dynamic environment. Systematic literature review revealed the research concerning artificial intelligence capability on HEIs performance still relatively scanty and need for further investigation. To address the gap, we proposed artificial intelligence capability model underpinning on Resources- Based View and Dynamic Capability in Higher Education Institutions. This paper contributes theoretically to the academic literatures, stakeholders and managerial practice by extending resources-based view and dynamic capability view to create better understanding of advanced artificial intelligence in Higher Education Institutions context.

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I. INTRODUCTION

The age of Artificial Intelligence (AI) advancements facilitates human beings to go beyond traditional computers to simulate, mimic human behavior, and surpass human intelligence (i. e sensing, reasoning, learning, forecasting and automated tasks). The advent of AI as a novel and unique technology has unlocked the latest learning trend in the HEIs sector attracted significant scholarly motivation have skyrocketed its popularity in HEIs. Currently, HEIs taking their first steps into the unchartered territory of the possibilities opened by advanced AI in the context of learning, teaching, research and Information Technology (IT) governance [1]. Indeed, this paradigm shift reflected the data-driven culture in HEIs as the influences of big data analytics (BDA) have bolstered the current wave of advanced AI. The adoption of advanced AI in HEIs has accelerated due to expanded datasets, improved complex algorithms, and generative AI. The significance of HEIs context as a frontier economic sector and evolving nature dynamically thus providing a rich setting for diverse stakeholders to comprehend the impact of advanced AI from predictive analytics to augmented AI technologies or AI-driven tools.

AI has accelerated pace, and this is already affecting the profound nature of education within HEIs [1]. The adop-

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tion of advanced AI in HEIs plays significant role in the improvement of the quality of education and learning and subsequent resolve HEIs issues [2]. Advanced AI empowered by goal-oriented, structured strategy towards agile organization management in HEIs. During the Fourth Industrial Revolution (4IR), the convergence of AI demonstrated by tools (i.e. Natural Language Processing (NLP), virtual and augmented reality simulation, OpenAI's Chat Generative Pretrained Transformer (ChatGPT), emotion recognition) gained popularity and reshaped the education landscape. AI's unique capability to revolutionize HEIs from several key distinguishing characteristics, incorporating human emulation, automation, predictability, self-learning and augmentation becoming significant research.

However, the benefits of advanced AI are not proportionately accessible to the HEIs sector, especially in developing countries. Past research and analysis on future evolutionary trends of AI and HEIs are being conducted by scholars and researchers in developing countries including Malaysia [3]. Unfortunately, these countries encounter inadequate infrastructure and connectivity, exacerbating the digital divide between urban and rural students and affordability issues. Advanced AI still early stage of education practices has brought perceived benefits, pressures and challenges for HEIs.

Traditional AI technologies are universally adopted while highly sophisticated capabilities of AI or advanced AI (i.e, genetic algorithm, deep learning) are still in the early stages of growth and have not yet been fully penetrated within HEIs. As a result, there is a lack of sound evidence available on AI adoption impact on HEIs performance as AI-based tools have not been widely adopted in HEIs [4]. The augmentation issues imply the collaboration of simple to complex tasks between AI and humans bringing benefits and added value in HEIs. Nevertheless, the automation of human replacement by AI requires further scientific exploration [5].

Given this AI and HEIs background, by addressing the research gaps based on formulated SLR AI findings [8], is the raison d'etre of this study and dynamically analyze the factors influencing AI adoption in HEIs context and develop a holistic AI-based framework within HEIs.

II. LITERATURE REVIEW

We adapt canonical reference by Russell & Norvig, 2021 to understand the evolution in the use of AI in HEIs literatures. Historically, the terms of AI systems were coined and idealize in the year 1956 by the father of AI renowned as JohnMcCarthy mathematician and at Dartmouth conference through AI project. The evolution discipline of AI arose from the 1960s to 1970s with the growth of heuristic programming techniques and the first neural networks with the establishment of situation control techniques for wide-ranging systems. The evolution of AI-based systems starts with artificial narrow intelligence (ANI), then continues with artificial general intelligence (AGI), and ultimately meets the level of artificial super intelligence (ASI), which is expected the surpass human capabilities in all dimensions of real-life learning in need for a regulation in future [9].

A. Defining Artificial Intelligence

Since AI evolved dynamically, there is no universally accepted and no perfect definition of AI indeed present a fundamental challenge of comprehensive understanding of AI in unified manner [10]. It is interpreted and understood considering several contemporary scientific vantage points. A common definition of AI is a technology that enables machines intelligence to mimic various complex human cognitive and skills. The technology perspective emphasize roles AI is software application or algorithms, machine intelligence and hardware technology for optimized AI workload that AI simulate human cognitive to perform automation complex tasks that were traditionally completed by humans cognitive abilities [11].

While from IT innovation and performance, AI as "a collection of tools and technology capable of augmenting and enhancing organizational performance" defined by [5]. In simple terms, AI is an assemblage of interrelated systems and technologies that impersonate the cognitive functions of the human mind for performing tasks, solving problems, making recommendations and decisions. AI conjures up images of machines with gigantic processing power supercomputers and the ability to adapt to their environment. The unique features of supercomputers human-like cognition and functionality, which in turn develops their human interactions [6].

A new hype and emergence of the use and application of AI in HEIs in the world has opened new benefits, challenges and possibilities for HEIs educational stakeholder. Nevertheless, we should take precautions and be aware of the real limits of AI algorithmic solutions in complex tasks in HEIs to minimize the challenges and risks of AI adoption. While the integration of artificial intelligence technology offers numerous advantages, it also entails various potential risks.

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B. Benefits Artificial Intelligence in HEIs

Investigating the implementation of AI in HEIs is indeed a timely and relevant topic that aligns with the rapid technology advancement. Recent advancements in technology, especially in AI, have been greatly enhanced by the ability of algorithms to learn on their own, the availability of large amounts of data, the increasing computational power of machines and advanced research discovery. This has resulted in AI-driven systems and technologies becoming more widespread and efficient, while also becoming more affordable and effective in solving HEIs myriad of complex operation by providing predictive analytics, automation capabilities and virtual assistant [7].

Advanced AI transforming the way HEIs operate and revolutionize the organization using natural language processing and machine learning algorithms to automate management routine tasks. It has the potential to improve university administration with value added activities, with automated systems, enhance student involvement using AI-powered chatbots and provide better staff assistance. AI technology is cutting-edge and can revolutionize teaching and learning in HEIs with machine learning, neural network dan deep learning. It is anticipated that AI will improve the governance of academic and non-academic operations and has extensive uses in enhancing learning, advance research, and administration efficiency [8]. AI in education can facilitate personalized and adaptive learning systems that customize information, activities, and feedback. It facilitated the individual requirements learning path and customization of diverse needs, interest and maximizing learning achievements. Thus, AI enhancing the students through engaging learning experiences integrated using virtual reality (VR), virtuality-reality continuum (VRC) augmented reality (AR) and gamification that simulate real-world experiences proactively [9, 10].

Clearly, AI brings significant benefits to HEIs in various facets such as automation, stability of AI- power predictive analytics, profitability using AI-driven data analytics, efficiencies in financial services power by Chatbots and virtual assistance, systemic risk surveillance and regulatory requirements using AI powered cybersecurity for safeguarding sensitive data and integrity in HEIs.

C. Challenges and risks of Artificial Intelligence in HEIs

This sub-section pinpoints some challenges and risks (i.e. technical challenges, pedagogical challenges) in AI adoption in HEIs environment dealing with probabilistic results [11, 12]. Although, there is past studies focused on challenges and risks of AI, such as data privacy, security, algorithmic bias and ethical issues [9, 13, 14, 15]. However, it is still fragmented categories to related to transparency, moral dilemma and erroneous use of AI in HEIs context.

D. Technical Challenges

Challenges in designing automated AI systems for the needs and structure of Higher Education Institutions (HEIs). Besides, the challenge is ensuring interoperability and compatibility of AI solutions with IT infrastructure capabilities in HEIs.

E. Pedagogical Challenges

Create AI-powered educational tools and platforms to improve learning results and accommodate various teaching approaches. Ensuring that AI applications in education foster creativity in multimedia, critical thinking, and collaboration among student teams [16].

F. Ethical Principles in AI use and Development

AI into practice has also created a wave of ethical concerns that ought to be identified and addressed in implementing AI technologies. AI's emulation capability particularly security, potential misuse and ethics in HEIs. The existence of algorithms trained on biased leads to discrimination outcomes and unfair treatment in decision making by stakeholders in HEIs. In addition, there is a lack of transparency in the AI decision-making process due to the complexity of system features, data-driven decisions that have errors and dynamic tendencies in the HEIs.

G. Challenge of AI's Emulation Capability

Nowadays, cyber security measures are built on technologies that recognize bot behavior from legitimate human behavior, but AI's emulation capability more accurately often allows hackers to avoid such detection. Thus, through AI emulation, cyberattack can use AI-powered attack accurately mimicking human behavior if the system still using traditional cybersecurity tool. The highly sophisticated AI-powered attacks (i.e. AI-power malware) by professional hackers enable bypass security defenses and infiltrate networks or systems undetected without triggering alarms or anomalies detection.

H. Challenge of Data Ownership and Privacy

A definite aspect related to AI is the right of access to data and data ownership. Although there are legal instruments such as data protection laws being the basis for regulating data access and data ownership. In addition, legal compliance involves trustworthiness [17] and privacy. These prin-

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ciples, ideas and values influence the legal rules, organizational standards, and continuous policies regarding how to reduce and mitigate the ethical difficulties that impede the deployment of AI in HEIs in future [18].

I. Artificial Intelligence Adoption and HEIs

Studying IT innovation adoption mechanisms at the individual and organizational level has a long tradition in information systems research. AI has the characteristic features of advancement, dynamic, complexity, spillover, and application, and it has widely and deeply penetrated various fields specifically HEIs. AI adoption is a form of IT innovation adoption, where an organization implements new technology, product, process, or practice involving the use of computer hardware and software to enhance operations, management, and decision-making. During this early stage, the excitement around the implementation of AI technology in HEIs is necessarily accompanied with a certain level of uncertainty.

AI is a general-purpose technology which is impactful innovation due to unique characteristic, specialized requirement and capabilities distinguishing it from other disruptive technology that are strike on harmonious equilibrium functionality with user-centric design, simplicity, accessibility and sophistication. The primary goal of implementing AI adoption is to lead to organizational performance. Thus, research on IT innovation adoption structures both individual and organizational level has a well-established history in information systems (IS) research to elucidate and study multi-facet factor of technology adoption [19]. IS research field has developed dominant and well-known theories and frameworks, for example, the technology acceptance model (TAM), Social Cognitive Theory (SCT) the diffusion of innovation (DOI) theory, the unified theory of acceptance, Resource Based View, Dynamic Capability View, Theory of Planned Behavior (TPB), Actor-Network Theory (ANT), Adoption-Diffusion-Implementation Continuum, Use of technology (UTAUT) and the TOE framework.

III. THEORETICAL FRAMEWORK

The advanced of AI capabilities, we have proposed a new model of the AI adoption integrated with specific AI capabilities (AIC) holistic approach to address AI unique challenges the research problem and navigate the complexities of AI adoption in dynamic HEIs asymmetric triple helix [11].

A. Artificial Intelligence Capability (AIC), RBV and DCV

Artificial Intelligence Capability (AIC) refer to "the ability of a firm to select, orchestrate, and leverage its AI-specific resources" [10]. To build AIC, this study proposed on the resource-based view (RBV) [20] and Dynamic Capability View (DCV) of the firm and seeks to examine internal resources, resource complementarity and resource reconfiguration with leveraged in environmental dynamism. Findings from past studies indicate that the RBV and DCV are appropriate and valuable theoretical lens for dynamic environments in HEIs. Specifically, RBV and DCV encourage resource complementarity and develop AI-specific capabilities to align and synergize toward overall HEIs performance, subsequently adapt to dynamic environment [21, 22, 23]. This study adapted AI capability and resources guided by [24] tangible, human and intangible.

B. AI Data Capability

Data are as lifeblood of AI, considering one of the primary enablers in leveraging the capability of AI by organization. AI data capability refers to the ability of AI effectively provide high- quality data, process, prepare, and interpret data to derive value from data to HEIs. Traditionally, organizations focused on structured and semi-structured data as guidance for decision-making, problem-solving and competitive advantages. In contemporary times, HEIs capture a vast array data and stemming data from multiple sources and in multiple formats require large volumes of high-quality data [11]. The availability of high-quality datasets is indispensable to train the AI algorithms, particularly in machine learning. Since AI systems require massive training datasets, AI "learn" from available data in a manner like the way humans learning process, there is a high requirement on large amounts of high-quality dataset. However, organizations still lack available data in large amount of quantity and high -quality data for AI model training. Therefore, we assume AI data capability to facilitate AI implementation in HEIs. Thus, we propose hypothesis 1 as below.

H1a: AI Data Capability has a positive relationship toward HEIs performance moderated by environmental dynamism.

C. AI Technical Skills

AI technical skills refer to the necessity to deal with the implementation and realization of AI algorithms, managing the infrastructure to support such initiatives, as well as those to introduce and ensure AI applications adhere to goals. It has been observed that specific AI generic skills require individuals with key skills in programming, logic, data structures, big data, language processing, and cognitive learning theory [25]. Due to investing heavily in utilizing knowledge-based AI-tools that are driven by large amounts of data, information and rules, hence, HEIs require

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upskilling individual in AI [26]. Finally, HEIs must ensure that AI systems are operating as expected and any unexpected issues, and unanticipated consequences are monitoring in detailed job function of performance AI system for example troubleshooting, patches and compliance. AI technical skills are becoming critical for HEIs as AI generic skills are currently scarce in the education sector and need more AI training. H1b proposed as below.

H1b: AI Technical Skills has a positive relationship toward HEIs performance moderated by environmental dynamism.

D. AI Management Capability

AI management capability potential is peculiar to strategic planning, strengthening relationships within and between companies, investment decision-making, coordination and control. It is the ability of an organization and staff to model intelligent behavior in a computer or technology to create added value for the organization's sustainability. Unsuccessful implemented of AI occurred if HEIs lacks data automation, structured analysis and cybersecurity issues. Furthermore, AI management capability must strong control on cybersecurity management to protect internal and external vulnerabilities. AI management capabilities catalyst on risk management by prioritizing refining algorithms for malware classification, intrusion detection and threatening intelligence sensing. Thus, we hypothesize that:

H1c: AI Management Capability has a positive relationship toward HEIs performance moderated by environmental dynamism.

E. Moderating Role of Environmental Dynamism (ED)

Environmental Dynamism (ED) can be define as "the volatility and unpredictability of the firm's external environment [27]". The moderating role of ED has gained significant attention from scholars over the past decade. Although the DCV has been increasingly used as one of the most important theoretical lenses for the existence of the underlying organizational routines, but also the context in which these capabilities are deployed. Scholars have recognized the role of ED as a potentially important contextual variable in HEIs compared to stable environment. ED is a key factor in DC theory which suggests that the differential effects of DC on organizational performance are contingent on the level of dynamism of the organisation's external environment by leveraging AI capabilities. Hence, based on these arguments, we hypothesize:

H2: Environmental dynamism has a positive moderating effect on HEIs performance.

F. HEIs Performance

Organizational performance (OP) represents multifaceted metrics of the organization to achieve holistic performance beyond financial metric (i.e. marketing performance, administrative performance, innovation). The combination RBV and DCV deemed fit to perceive business values through the process of AIC, automation effect, data informational effect or data effect, transformational effect and innovation performance towards HEIs performance [28]. Thus, with game-changing innovations juxtaposed with advance of AI, HEIs require an exponential pace to stay relevant and stay ahead of the curve to fuel future growth.

G. Financial Performance

The ability of the organization to attain financial resilience profitability, minimize cost by reducing unnecessary expense s, leverage profit margin, reallocate funds, reduction of staff through automation, predictive using AI-powered predictive analysis, optimize resources allocation and elevation of revenue-generating activities.

H. Marketing Performance

HEIs, as organizations align the marketing strategies to create value for the company's customers, typically refer to undergraduate and post-graduate students, international students and professional life-long learning students. For example, personalized AI technology machine learning algorithms to understand from student perspectives using AI predictive analytics and predictive market trend in HEIs [9] HEIs also optimized digital advertising using AI ad platforms across multiple social media platforms with organizational agility response low market turbulence.

I. Administrative Performance

Administrative performance refers to processes and daily tasks to implement and designed in organization to gain efficiencies and effectiveness to support organization's overall objectives. Integration of AI-driven system s and HEIs can reduce workload on administrative staff and academician using AI-power chatbots to handle routine inquiries from students, alumni and staff in HEIs. AI driven document management system able to streamline administrative workflows and automate the process to minimize errors, automatic grading, speed-up responses time and maintain automating repetitive tasks efficiently.

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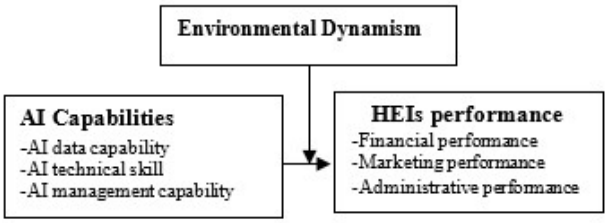

Fig. 1. Model of Advanced Artificial Intelligence in HEIs

IV. RESEARCH DESIGN AND METHODOLOGY

This study is an early investigation of AI applications adoption at the organizational level, incorporating well established theories into a novel innovation. For the quantitative study, the data will be analyzed using SPSS 28.0, and SmartPLS4. A two-stage approach that incorporates partial least squares structural equation modeling (PLS-SEM) with artificial neural network (ANN) will be utilized to analyze survey data in Malaysia and Pakistan. The questionnaire will develop clear and compelling communication and professional to encourage the rate of response and will use an e-survey questionnaire to collect data from HEIs respondents. Thematically, the questionnaire focused on a variety of interconnected factors based on the conceptual RBV and DCV model.

V. CONCLUSION AND FUTURE WORK

As theoretical contribution, this study explores how AI capabilities identify avenues for improving HEIs performance by focusing on tangible and intangible factors from RBV and DCV theories at organizational level perspectives. Clearly, the development of AIC significantly transformed the educational world by sharpening the AI skills and providing a collaborative learning environment in the HEI with significant implications for the near future. In reality, AIC HEIs research model provides a foundation for future research on how HEIs deploy and perceive the benefits of AI toward HEIs performance with dynamic environment. It can be used as a starting point for further in-depth investigation on AIC in HEIs.

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